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A Contribution to the Problem Concerning a Procedure For Anemoenergetic (Wind Power) Computations

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[Note: The following report appeared in the regular "Brief Communications and Articles" section of the monthly scientific-technical journal Meteorologiya i Gidrologiya, No. 3 (November 1950), pages 57-59.]

E Existing types of wind motors can utilize winds starting with a certain value of their velocity. The power of these motors depends also upon the velocity of the wind (the power can be considered as proportional to the cube of the wind velocity). Consequently, for wind-energy calculations it is necessary that the data on winds in climatological handbooks should be represented in the form of the frequency, or recurrence, of the various wind velocities.

The data available in existing climatological handbooks is insufficiently pertinent for this purpose, since too rough gradations are employed in them for wind velocities; it is desirable to have the frequency for each meter [sic]. Moreover, the handbooks contain data of certain stations which are located not in an open place, whereas anemo-electrical (wind-electrical) power plants will obviously be designed for places as open as possible.

The possibility arises of working out all over again the data of supplementary stations, sometimes of comparatively short operation. As is known, this work of processing the data is tremendous, and moreover the frequency of the individual values of wind velocity can be so small that a series of observations over 10 to 15 years will not give sufficiently stable distribution curve. To this is also added the fact that many observers give clear preferences to some wind velocities over others, which obviously causes a distorted velocity distribution.

There is another way, which is very remarkable from the point of view of shortening the tremendous computational work and was recommended in the text-book of Ye. M. Fateyev (Vetrodvigateli [Wind Motors], published 1946 by Gos-energo-isdat [State Power Press]). This method consists of the following: determine only the mean yearly wind velocity, and then construct, in a purely theoretical manner, according to this mean yearly velocity the curves of wind-velocity distribution (for each meter [of height]). The dependence of the velocity distribution upon mean yearly velocity has already been investigated by M. M. Pomortsev in 1894, and afterwards by Gullen [Hullen, Hoollen, Houllen?] in 1925. The Central Wind-~~Energy~~ Power Engineering Institute [Tsentral'nyy Vetro-energeticheskiy Institut,] during tests of these dependences, found it possible to recommend Pomortsev's curves for those regions [geographical] where the mean yearly wind-velocity does not exceed 5 m/sec, and Gullen's curves were recommended for those regions with higher wind-velocities. It seems, however, too dangerous for us to extend this data, clearly verified only for several points, to any arbitrary regions [geographical]. Indirect proof of this is the great divergence between the curves of Pomartsev and Gullen, even in the case of those mean yearly velocities which in the opinion of the Central Wind- Power Eng. ~~Energy~~ Institute, are the boundary between the regions [geographical] of applicability and of other curves.

We attempted to test their applicability using as examples two stations in Omsk Oblast, by computing (for 12 years) the mean wind velocity and velocity distribution according to certain rough gradations (0-3, 4-5, 6-8, 9-12, greater than 12 m/sec). The results are shown in table 1.

The frequency of wind velocities was computed from the usual four period observations (1, 7, 13, 1900), but not from the hourly observations, which would, of course, have been more accurate, but it seemed to us that this could

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not essentially effect the results. Our calculations indicated the great magnitude of the errors obtained during use of the theoretical curves, especially when using Pomortsev's curves, which are recommended by the Central Wind Power Institute for small mean yearly wind velocities.

Gullen's curves were closer to the observational data (especially for Isyl' - Kul'). For the Poltavka stations, considerable divergences were obtained. This indicates that the theoretical wind-velocity distribution can deviate essentially from the actual (factual) distribution.

It would be expedient to utilize the following method employed by us: selecting some rough gradation of wind velocities (we took the above-indicated gradations agreeing with the energy ones, but of course we can select others than these), we processed (manipulated) the observations in accordance with these gradations; then we converted the summarized resulting data into hours and distributed the numbers obtained within each gradation, all the while orienting ourselves by Gullen's curves, but following also the smooth course of the curve. Computation of the mean wind velocity according to the obtained magnitudes of frequencies also serves as verification (a check): if it [mean wind velocity] does not coincide with the earlier computed method, then it is necessary to introduce corrections into the velocity distribution.

It seemed sufficient to us to carry out such processing for a period of 13 years (since 1936, in order to use only periodic observations) and moreover for a very limited number of stations.

Our experience (and we processed a considerable number of stations for a small territory under investigation) confirmed again the position, already stated frequently, that the wind velocity depends greatly upon the disposition of the meteorological station, degree of protectedness of the wind cone [flyuger] and "roughness " of the Earth's surface (in particular, upon the presence of forested plantings), rather than upon macroclimatic conditions.

Therefore it is more expedient (at least under conditions of a lowland locality or region): a) to select for each climatic zone 1 or 2 stations, but on the other hand with the requisite observations and completely representative set-ups disposed sufficiently openly under conditions typical for the given zone, and b) to carry out all processing only for these stations, extending the results of processing to the entire zone. It is necessary, however, to remind ourselves of the fact that the very selection itself of a representative station is not so simple; for example, in our processing of data for the forest steppe and steppe regions of Omsk Oblast, the selection could be done with sufficient definiteness only after the observations of 8 stations had been processed and critically analyzed, from which 8 stations we later selected two: namely, Poltavka for a perfectly open position and Isyl'-Kul' with forested plantings disposed close to the station.

The final results can be given in a different form: in the form of a frequency of various velocities or in the form of the total number of hours with wind of a given strength. The entire processing, of course, must not be limited only by the mean yearly quantities: for agricultural undertakings, obviously, it is very important to have a wind-velocity distribution according to the seasons, and also according to the times of the 24-hoursday; and we possess the complete possibility, by employing periodic observations, of giving the suitable corresponding characteristics (although for very rough gradations of the wind velocities).

Another important problem, encountered by climatologists during their work of processing the data of observations for computations of wind power [energy], is connected with the height at which we give the wind velocity.

Wind cones of meteorological stations are disposed at various heights, but very often at the height of 8-12 meters from the ground, mostly; whereas wind motors can be erected to considerably greater heights (in each case of the order of about 20 meters). Since the wind velocity increases with height, it is necessary to make a transition from the height of the wind cone /flyuger/ to a greater height; here not simply for the mean velocity, but for the frequency of velocities. In our work it did not seem possible to use some data of direct observations and we had to return to theoretical considerations according to sources in the literature. It is possible, for example, to use the familiar power law governing the variation of wind velocity with height and in this way to obtain the magnitudes of mean wind velocities at that height for which we need the information.

There still remains the transition (passage) from the mean velocity to the frequency of velocities. Since there are no actual observations at our disposal in the given case, the employment of theoretical curves, as was indicated above, cannot be admitted as reliable without further verification of these curves, and it is necessary to utilize any indirect oblique method or procedure. We employed the following method: The magnitudes of the mean monthly wind velocities were compared with the frequency of winds in definitely determined gradations of wind velocity for a given month (for example, more than 3 or more than 5 m/sec). We constructed the correlational graphs showing the dependence between these quantities; here it turned out that the points (there were 144 of them on each graph) lay sufficiently close, and the dependence was clearly rectilinear (here the dependence was almost identical for both stations under consideration). Afterwards, according to the mean velocities for the 20-meter height, the magnitudes of the frequencies for a wind of definite strength were read off the graphs (more accurate than the average number of hours per 24-hour day), and in this way we obtained "the base points", according to which the complete curve showing frequency was already constructed, just as was expounded above for the case of velocities at the height of the wind cone.

Of course such computations always include in themselves a certain element of arbitrariness and can have only an orientational significance, but in the absence of data of direct observations it is inescapably necessary to utilize some indirect oblique method or other. In each case we could not consider it possible, thus, justifying the absence of data, to leave the solution of this problem to the engineer power-expert himself, who will be compelled just the same to do the proper corresponding computations, but who will possess even less basic data for this than the climatologist will have.

It would follow that the program of several observatories (in the various "landscape zones" /landshafnaya zona/) should include the working-out of the problem concerning the variation of wind velocity with height (by way of observations according to a series of anemometers set up on high places or on masts); such data is very necessary for the solution of very many problems connected with engineering and technical computations.

/Table 1 follows/

Station	Method of Obtaining the Data	Number of Hours Per Year with Velocity of Wind, meter/second					Mean Yearly Velocity of Wind, meter/second
		0-3	4-5	6-8	9-12	12	
Isyl'-Kul'	Pomortsev	2966	2935	2440	409	10	
	Gullen	4153	2130	1632	686	159	4.4 m/sec
	Actual Observ.	4209	2223	1579	501	248	
Poltavka	Pomortsev	2238	2755	3060	681	26	
	Gullen	3545	2100	1890	950	275	4.9 m/sec
	Actual Observ.	3835	2221	1540	979	185	

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